6 Hillsdale Lake

6.1 General Background

Hillsdale Lake was impounded on 19 September 1981 and reached full pool on 23 February 1985. The main threats to water quality in Hillsdale Lake are nutrients, sedimentation, herbicides, and hydrologic changes related to urban sprawl in the northern reaches of the watershed. The lake is listed on Kansas's 303(d) list for water quality impairment due to eutrophication. Therefore, a TMDL was approved in 2001 to address nutrient control within the watershed. The TMDL goal for Hillsdale Lake is a reduction in the lake's trophic state index (TSI) from fully eutrophic (TSI = 59) to slightly eutrophic (TSI < 55), which requires a 46% reduction in the total annual phosphorus load to the lake. Concerned citizens within the watershed initiated the Hillsdale Water Quality Project (HWQP) in 1991 due to concerns of drinking water protection and recreational use. Since 1993, more than $2 million has been received by the HWQP to improve, monitor, and restore water quality in the lake. In addition, the city of Spring Hill initiated efforts in 2005 to develop a WRAPS project within the upper reaches of Hillsdale Lake watershed to protect their drinking water source.

6.1.1 Location

The lake is located approximately 8 km (5 miles) northwest of Paola, Kansas. The dam, built on Big Bull Creek, is located 29.1 km (18.2 miles) upstream of the confluence with the Marais des Cygnes River. The watershed includes southern Johnson County, southwest Douglas County, Franklin County, and Miami County. This area includes the expanding communities of Spring Hill, Edgerton, and Gardner. Historic water quality sample sites at Hillsdale Lake include 3 lake, 1 outflow, and limited inflow data from 3-4 sites (Figure 6.1)

6.1.2 Authorized Purposes: flood control, water supply, water quality improvement, recreation, and fish and wildlife management.

6.1.3 Lake and Watershed Data

Pools	Surface Elevation (ft. above m.s.l.)	Current Capacity (1000 AF)	Surface Area (A)	Shoreline (miles)
Flood Control	931.0	83.6	7,413	
Multipurpose	917.0	76.3	4,575	51
Total		159.9		

Total watershed area: 144 sq miles (92,160 A)
Watershed ratio: 12.44 FC / 20.12 MP

Average Annual Inflow: 92,831 acre-feet (1982 – 2004)
Average Annual outflow: 000 acre-feet
Sediment inflow: 1,928 acre-feet (1981 – 1991)

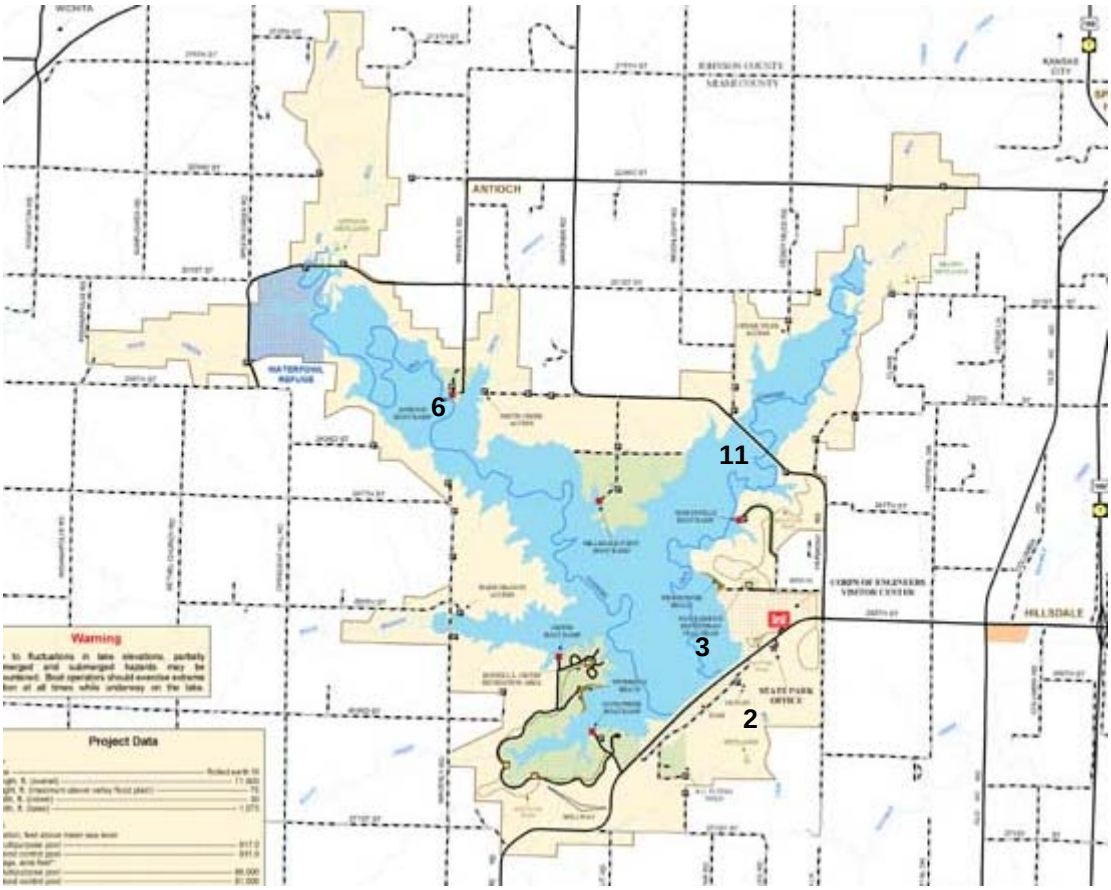

Figure 6.1. Hillsdale Lake area map with sample site locations and sample numbers.

6.2 2005 Activities

A train accident occurred on 4 February 2005 near Wellsville, Kansas, which resulted in the spill of #2 diesel fuel into Rock Creek. Precautionary booms were deployed at various locations of Rock Creek, west of the lake, to absorb petroleum as it moved down the stream (Figure 6.2). Samples analyzed by Pace Analytical Lab were within water quality standards and did not pose an environmental threat within the lake.

Jim Bell (OF-HD) provided field sampling assistance during 2005, as well as providing a historic perspective of the lake and watershed. Jim also hosted the Water Quality Programs inaugural AAR meeting in October. Lew Ruona, OF-CL Operations Manager, provided insight and background regarding Harlan County Lake.

6.3 2005 Data

Comparative historic data consists of monthly (April – September) data collected from 1999 through 2005.

6.3.2 Inflow

No inflow samples were collected from Hillsdale Lake during 2005.

Figure 6.2. Petroleum boom deployed to contain diesel spill from train derailment on 4 February 2005.

6.3.3 Lake

Total nitrogen (TN) concentrations from surface samples are very consistent between the three lake sites, with median values of samples collected between 1999 and 2005 ranging from 0.92 – 0.95 mg/L (Figure 6.3). The median value for samples collected from the outfall was 0.37 mg/L, which just exceeded the proposed EPA ecoregional nutrient criteria value of 0.36 mg/L TN. As expected, the lake exhibits annual and monthly variability in TN concentrations. Typically, TN concentration peaks in spring following runoff inputs and then declines through summer months as it is assimilated within the lake; see Figure 6.4 for an example from Site 3.

Total phosphorus (TP) concentrations are low compared to other district lakes, with median values ranging from 0.04 – 0.07 mg/L (Figure 6.5). The highest concentrations within the lake have been measured at Site 6 -- Rock Creek (Figure 6.6). All values exceed EPA's proposed ecoregional nutrient criteria value of 0.02 mg/L.

The ratio of TN:TP can be used as a surrogate to determine the dominant algal community within a waterbody. Ratios $\geq$ 20:1 are indicative of desirable algal communities, whereas ratios $\leq$ 12:1 are indicative of bloom-forming cyanobacteria (blue green algae). As would be expected, there is high monthly and annual variability in the TN:TP ratio at all sites; see Figure 6.6 as an example from Site 3. Median TN:TP ratios from the tributary sites were slightly greater than 12, indicating the lake could potentially be at risk for cyanobacteria blooms (Figure 6.7). Incidentally, no microcystis toxins were detected in Hillsdale during a single sample collected during 2001 by the University of Missouri – Columbia (Dr. Jennifer Graham – USGS, personal communication).

Median chlorophyll a values ranged from 6.2 – 14.3 ug/L from the three lake sites (Figure 6.8), with the highest concentrations measured at Site 6. There is an increasing trend in chlorophyll a at all three lake sites during the past four years; see Figure 6.9 from Site 6 as an example. The elevated chlorophyll concentrations at Site 6 correspond with higher concentrations of TP.

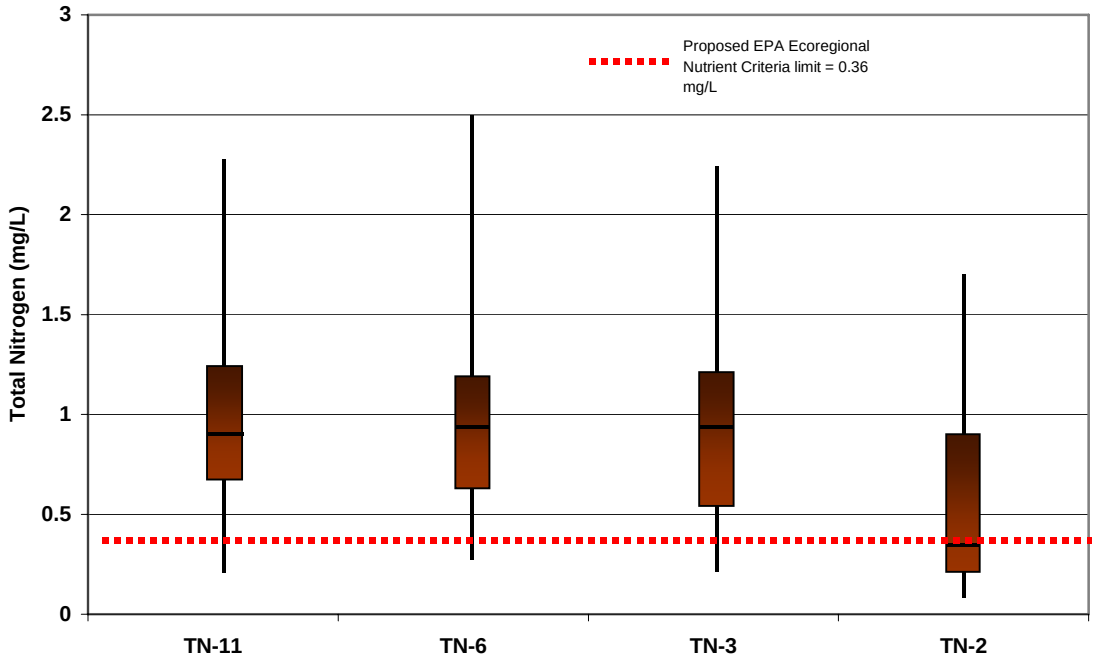

Figure 6.3. Box plots of surface water sample total nitrogen concentrations measured by site from 1999 through 2005 at Hillsdale Lake.

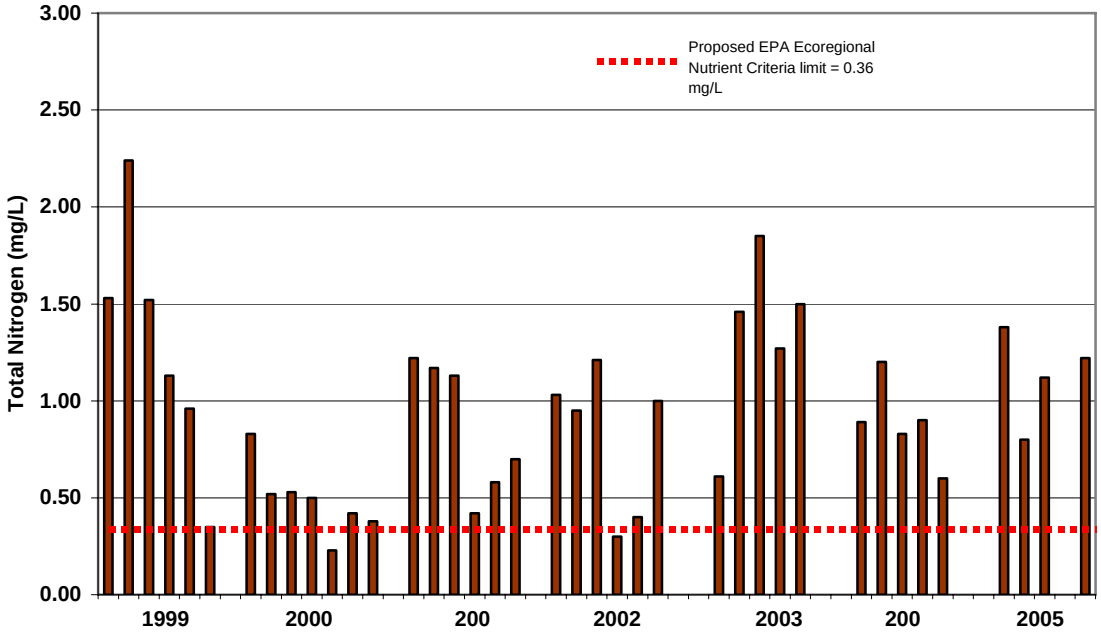

Figure 6.4. Total nitrogen concentrations by sample date collected at Site 3 (Tower) from 1999 through 2005 at Hillsdale Lake.

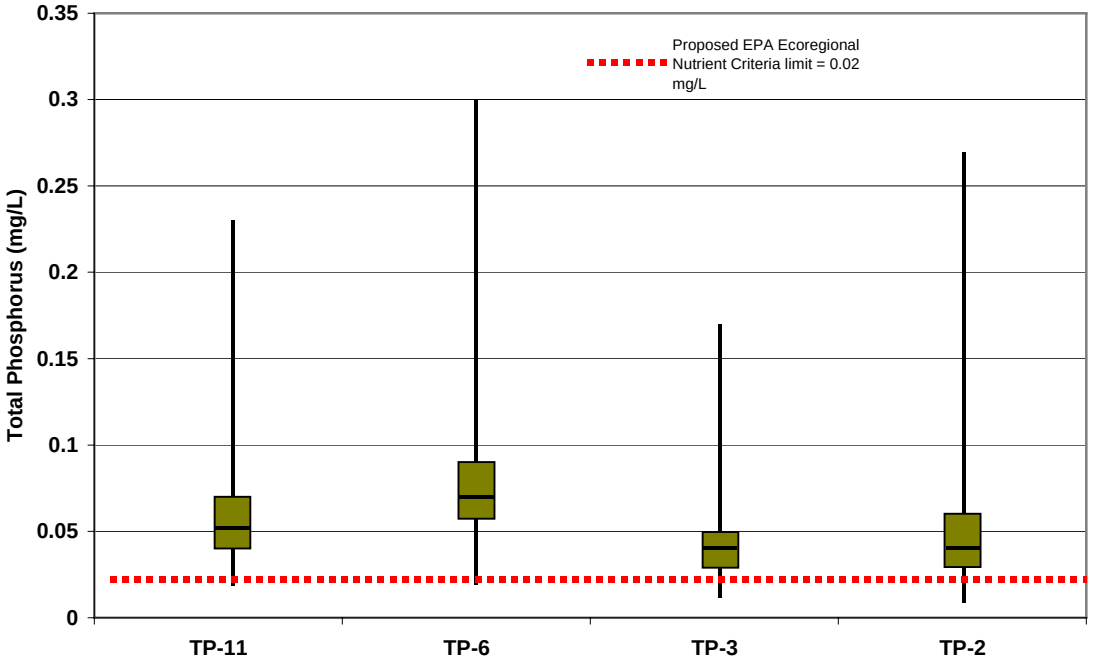

Figure 6.5. Box plots of surface water sample total phosphorus concentrations measured by site from 1999 through 2005 at Hillsdale Lake.

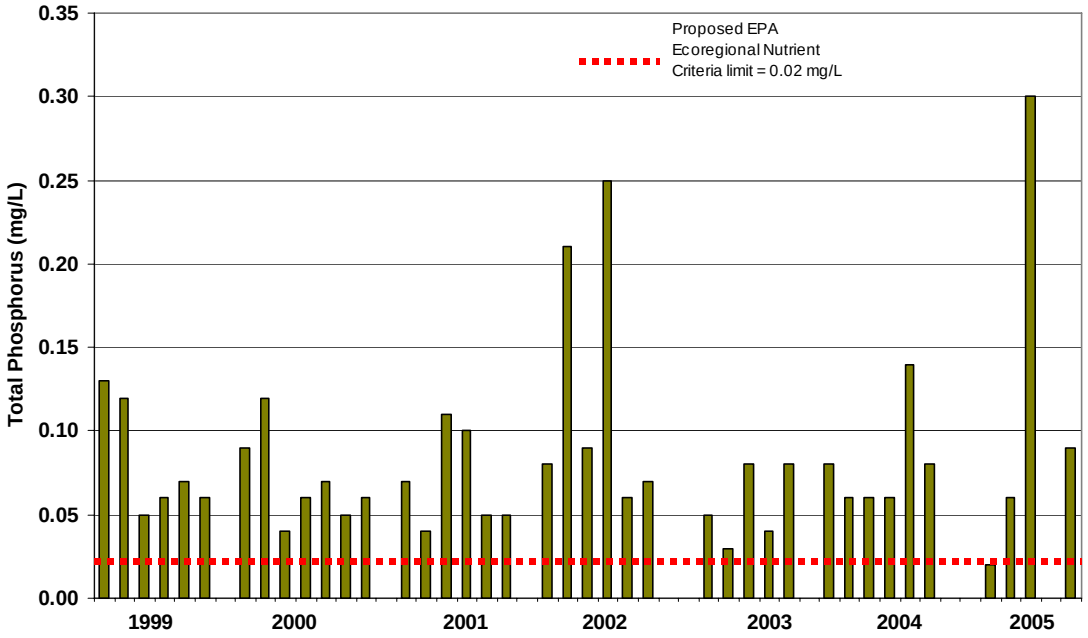

Figure 6.6. Total phosphorus concentrations by sample date collected at Site 6 (Rock Creek) from 1999 through 2005 at Hillsdale Lake.

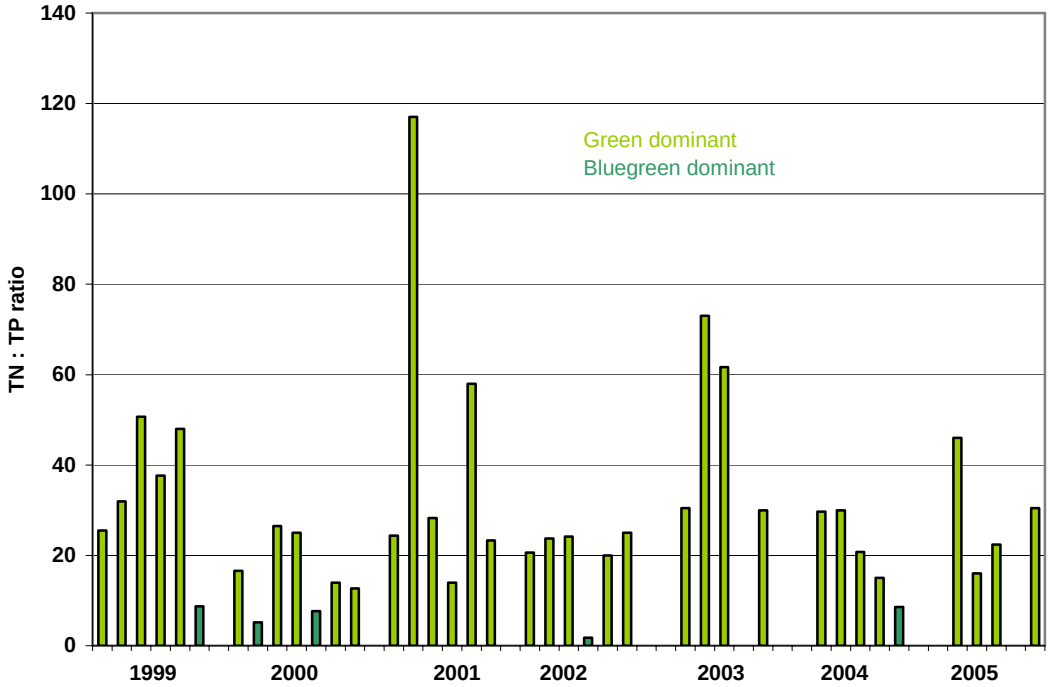

Figure 6.6. Graph of total nitrogen : total phosphorous (TN : TP) ratio by sample date at Site 3 from 1999 through 2005 at Hillsdale Lake.

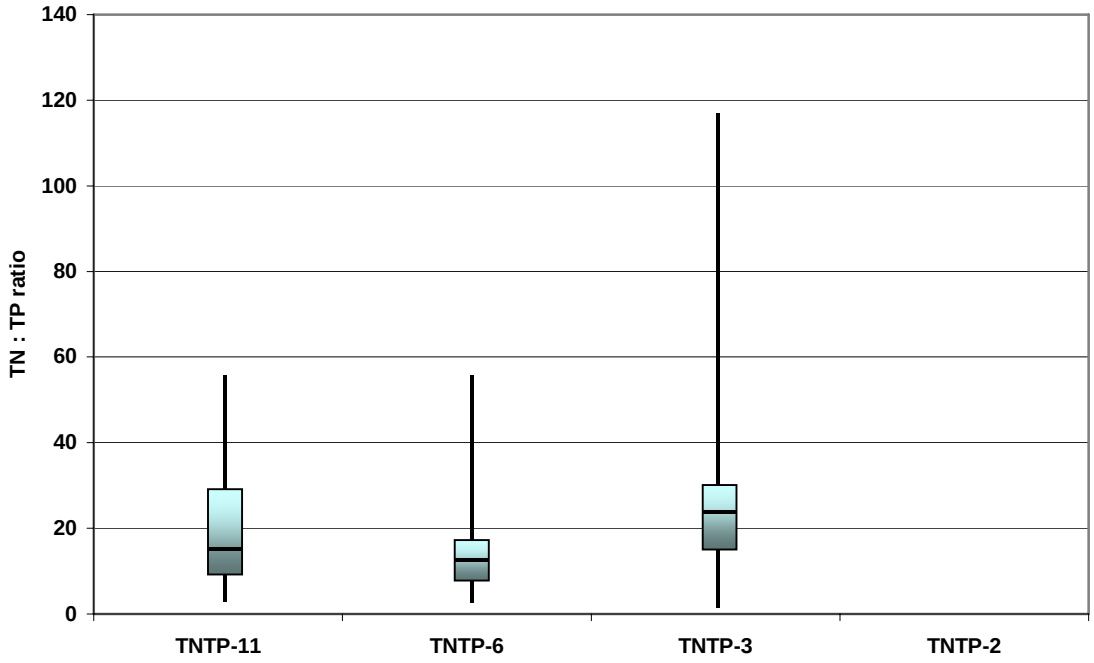

Figure 6.7. Box plots of total nitrogen : total phosphorus ratio (TN:TP) by site from 1999 through 2005 at Hillsdale Lake.

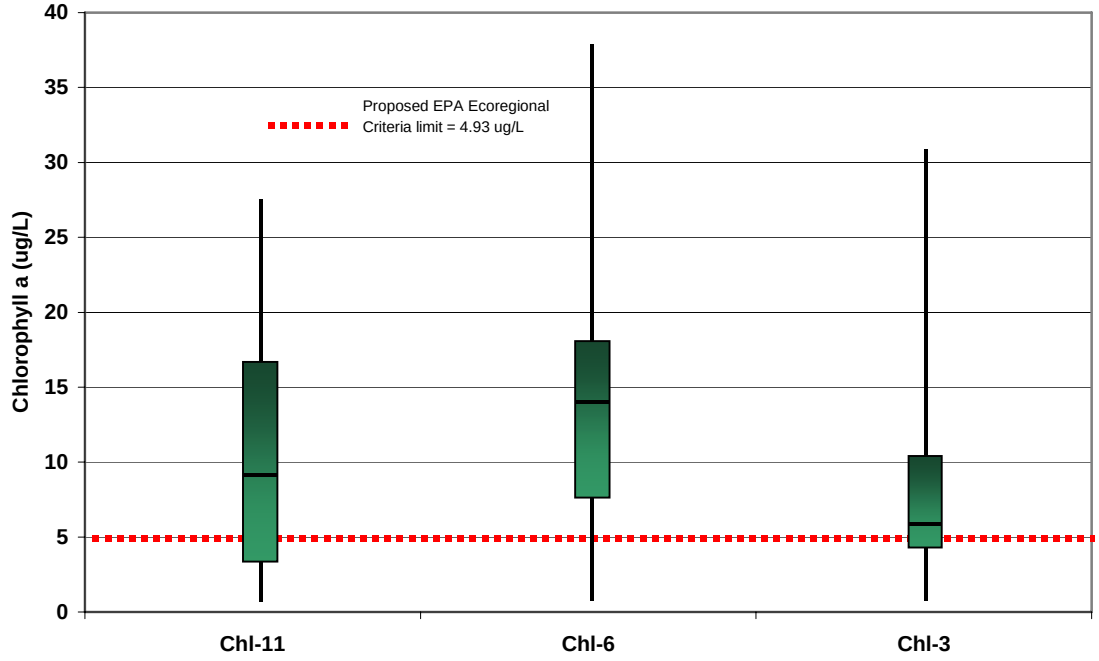

Figure 6.8. Box plots of chlorophyll a concentrations measured by site from 1999 through 2005 at Hillsdale Lake.

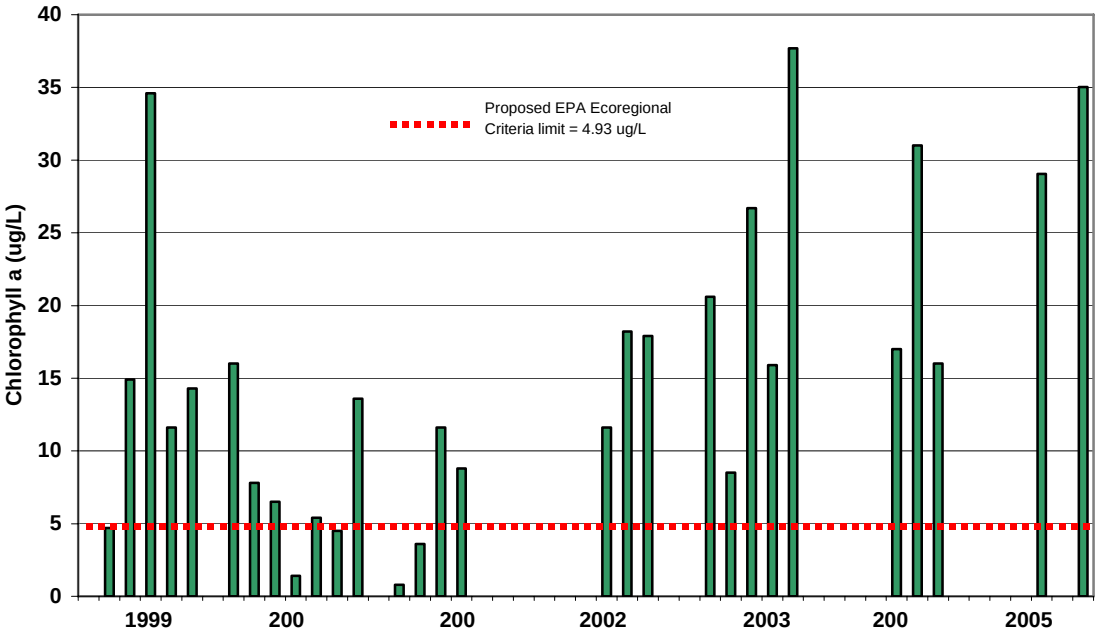

Figure 6.9. Chlorophyll a concentrations by sample date at Site 6 from 1999 through 2005 at Hillsdale Lake.

Differences in secchi depth measurements (0.5 – 0.91 m) were observed between the three lake sites, as depicted in Figure 6.10. The lowest secchi depths are measured at Site 6, which corresponds to the elevated TP and chlorophyll a concentrations. Annual and monthly variability in secchi depth measurements are depicted in Figures 6.11 (Site 3 -- dam) and 6.12 (Site 6 – Rock Creek arm).

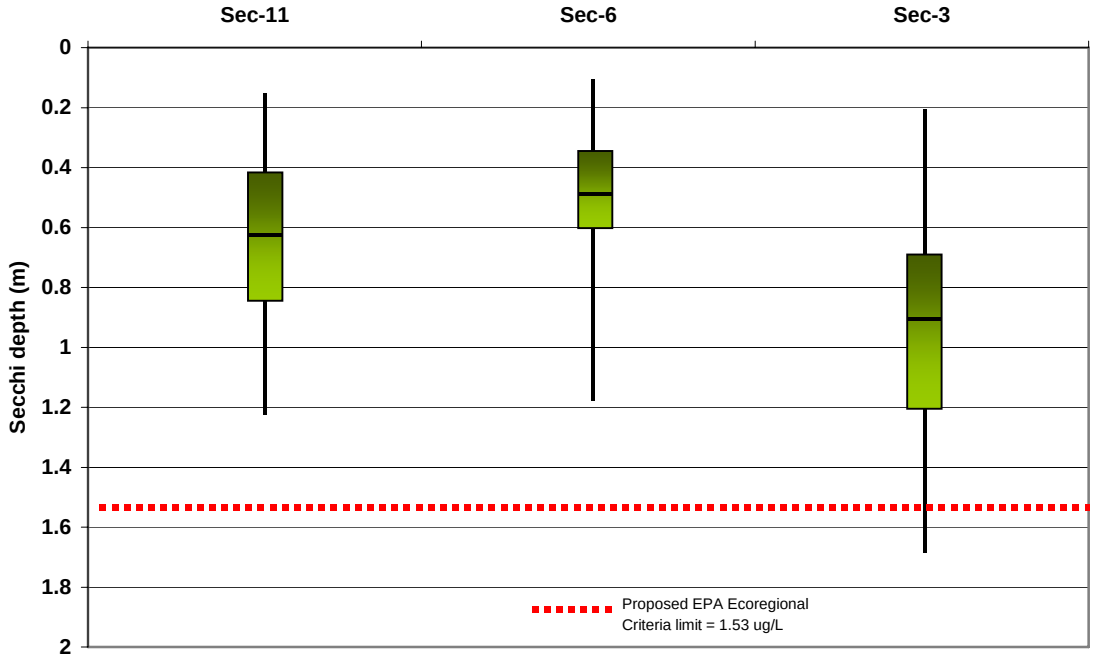

Figure 6.10. Box plots of secchi depth measured by site from 1999 through 2005 at Hillsdale Lake.

Median atrazine concentrations ranged from 1.7 – 1.9 ug/L for samples collected from 1999 through 2002 and again in 2004 (Figure 6.13). The peak concentration within the lake occurred in 2002, when samples collected from Site 6 (Rock Creek arm) during May through September exceeded the EPA drinking water maximum contaminant level of 3 ug/L (Figure 6.14). Similar, albeit lower, atrazine concentration exceedences were measured from Site 11 during 2002 (Figure 6.15).

Total iron exceeded EPA's Drinking Water Standard of Secondary Maximum Contaminant Levels (SMCL) of 300 ug/L from surface and bottom samples collected during early June 2001 at all three lake sites. Concentrations ranged from 434 – 640 ug/L on the surface and 1243 – 3366 ug/L near the bottom, with the highest concentration recorded at Site 3 (dam). Implications are directed at drinking water facilities related to taste and staining issues. In addition, all surface samples collected during August exceeded EPA's SMCL for manganese (50 ug/L). Sample concentrations ranged from 58 – 108 ug/L at the surface and 143 – 2767 ug/L near the bottom, with highest concentrations measured at Site 3 (dam). Implications are directed at drinking water facilities due to taste and stain issues.

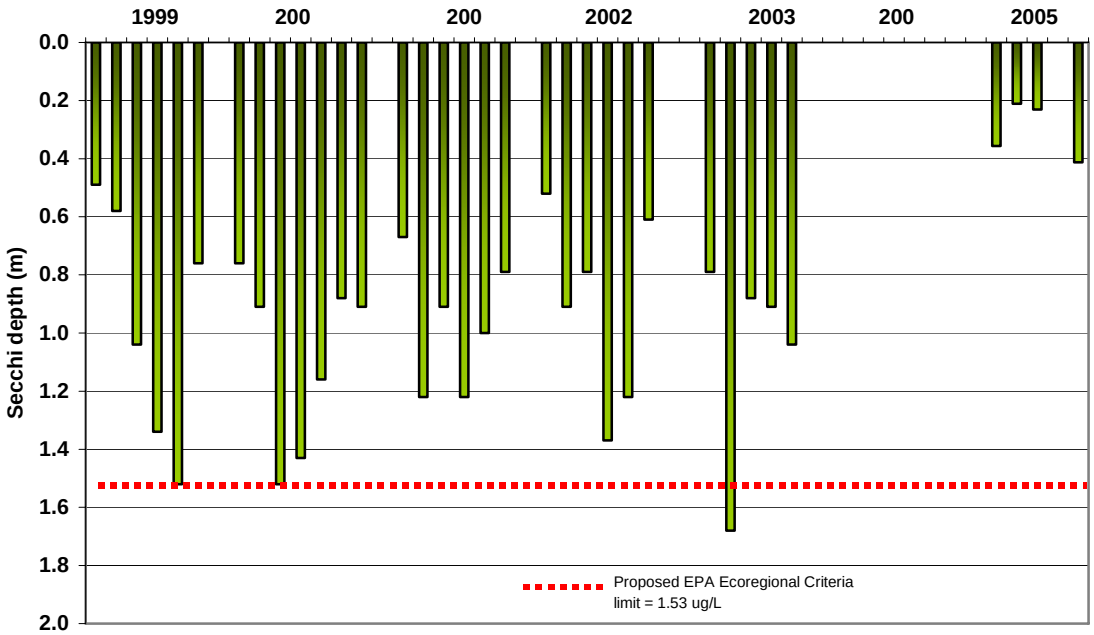

Figure 6.11. Secchi depth measurements by sample date from 1999 through 2005 at Hillsdale Lake Site 3.

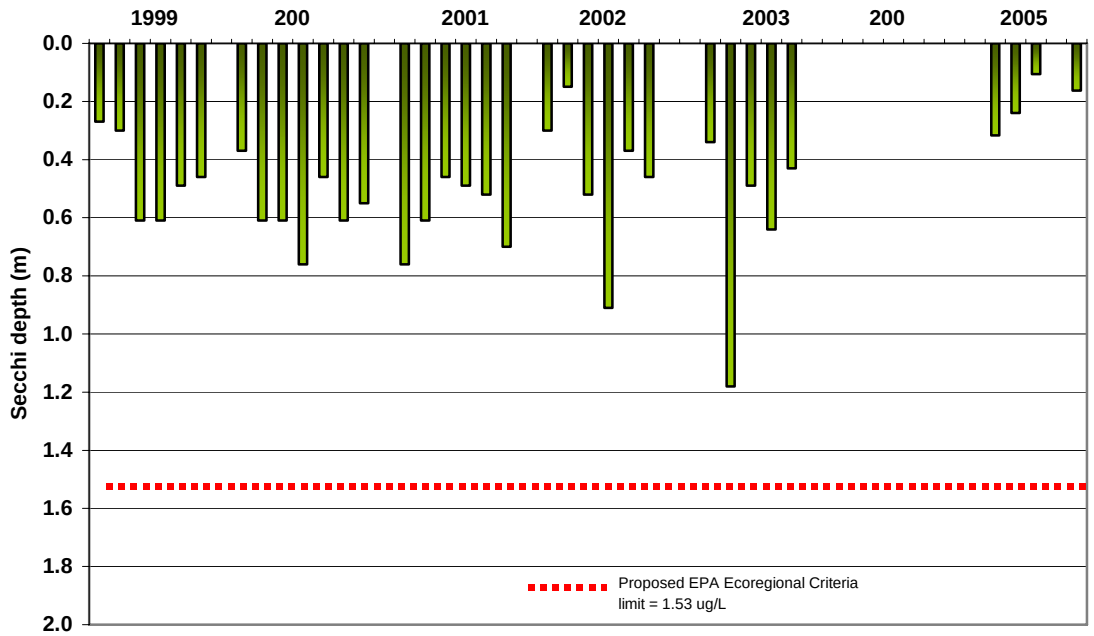

Figure 6.12. Secchi depth measurements by sample date from 1999 through 2005 at Hillsdale Lake Site 6.

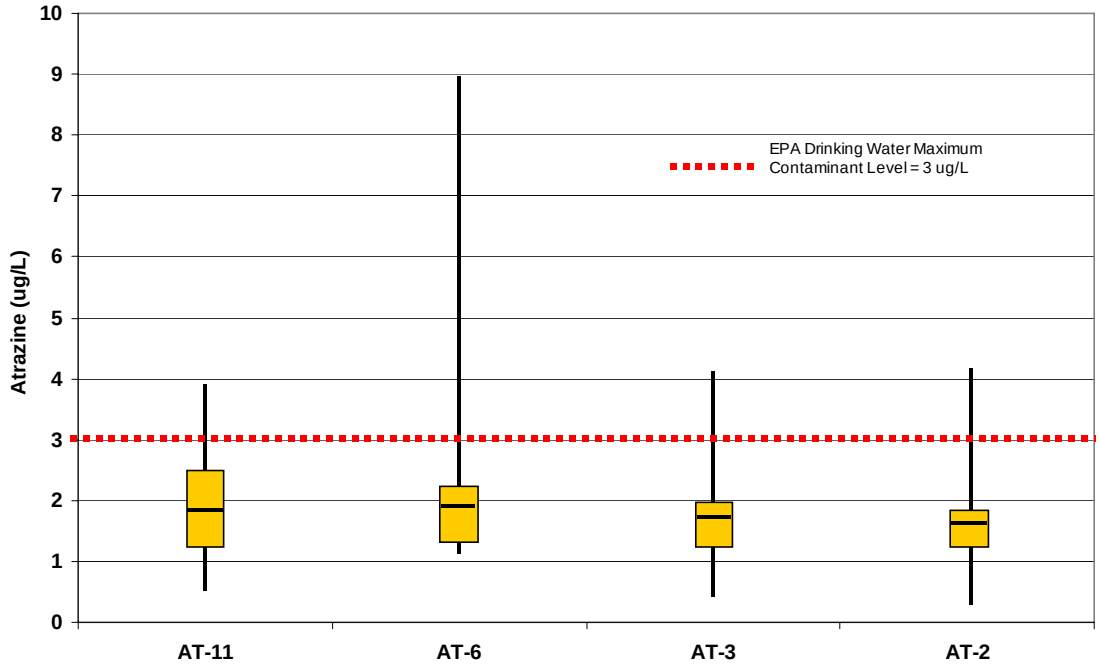

Figure 6.13. Box plots of surface water sample atrazine concentrations measured at lake sites and outflow (Site 2) from 1999 through 2005 at Hillsdale Lake.

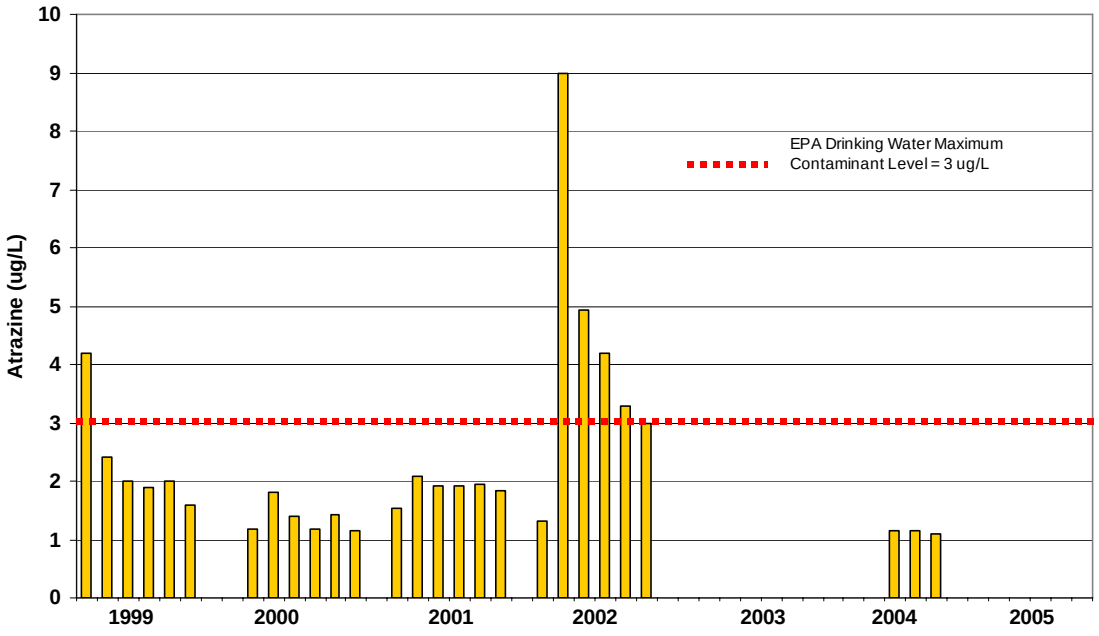

Figure 6.14. Atrazine concentrations by sample date collected at Hillsdale Lake's Site 6 (Big Bull / Rock Creek arm) from 1999 through 2002, and 2003.

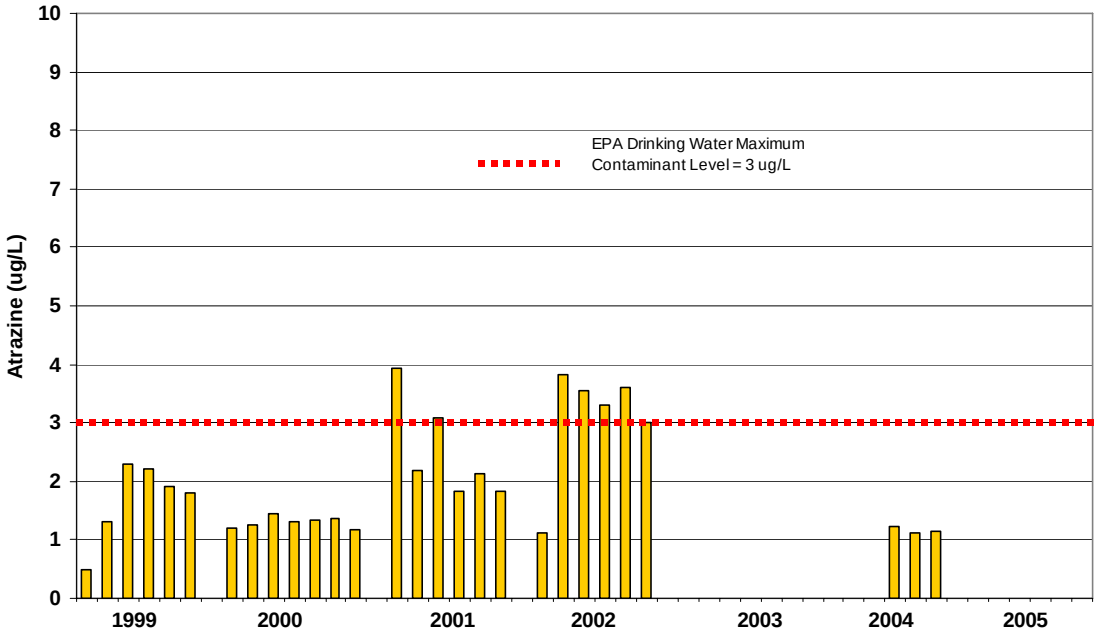

Figure 6.15. Atrazine concentrations by sample date collected at Hillsdale Lake's Site 11 (Little Bull / Spring Creek arm) from 1999 through 2002, and 2003.

Vertical profiles were recorded during monthly sampling trips to Hillsdale Lake in 2005. Parameters included temperature, dissolved oxygen, pH, conductivity, and turbidity. Typical of smaller, eutrophic Midwest reservoirs, the lake stratifies both thermally and chemically. The lake stratified thermally between 5-6 m during June and July, while DO concentrations dropped below 5 ppm at 2 m depth (Figure 6.16). The lake was undergoing fall turn-over during the late September sample trip based on temperature and DO measurements.

6.3.4 Outflow

No outflow samples were collected from Hillsdale Lake during 2005.

6.4 Future Activities and Recommendations

Sampling activities for 2006 will include continuation of monthly 'ambient' monitoring from May through September, as well as conducting monthly vertical profiles at each of the three lake sites. Bluegreen algae vertical distribution within the water column will be examined during the summer and compared to TP concentrations measured from surface samples. A contaminant group of interest for Hillsdale Lake are PAHs, which are typical components of asphalt, fuels, oils, and grease. These compounds enter the lake during stormwater runoff, and with a rapidly urbanizing watershed it is expected that such concentrations will increase.

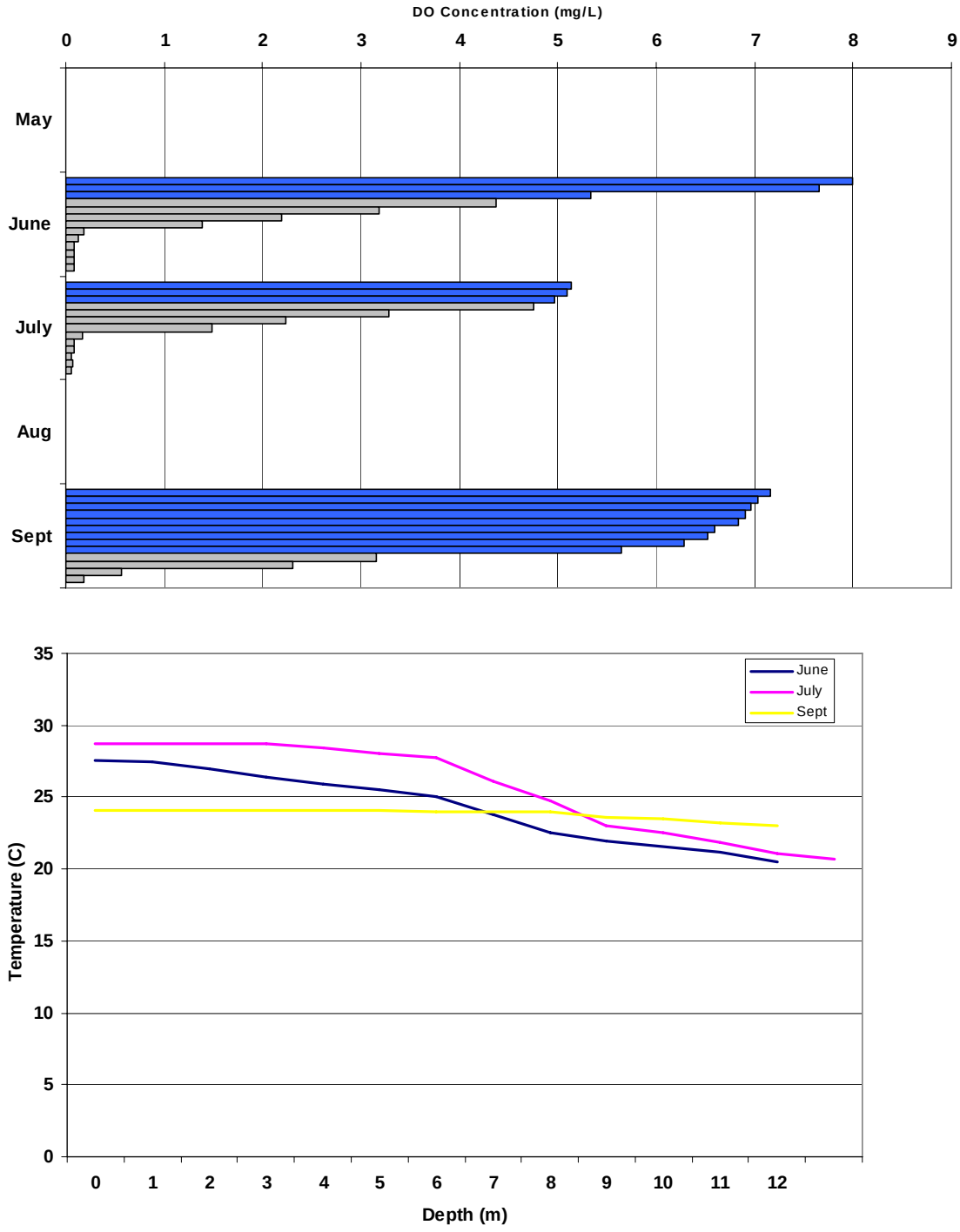

Figure 6.16. Dissolved oxygen concentration (mg/L) histogram and temperature (C) plots by sample dates from vertical profiles recorded at Site 3 during 2005 at Hillsdale Lake.